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EXPERIMENT STATION

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DECEMBER, 1888

CORN—FERTILIZER EXPERIMENTS

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ON THE FARM OF THE OHIO STATE UNIVERSITY
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Ohio Agricultural Experiment Station

BULLETIN NO. 7

AGRICULTURAL DEPARTMENT

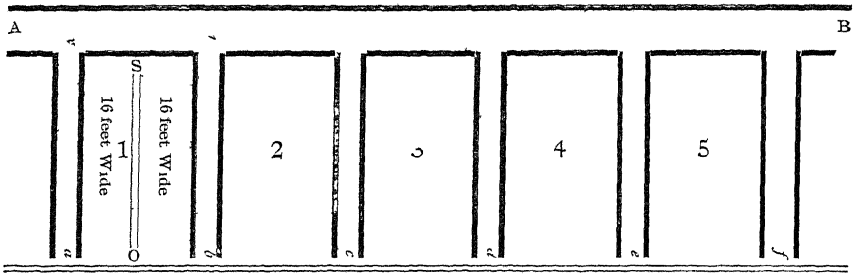
Experiments with Fertilizers on Corn

With the change of workers at the Station at the beginning of 1888, the old plan of work with commercial fertilizers on corn was wholly dropped and work begun on a different line, not wholly new, but probably more systematic; and while it is not as extensive, yet it will in a measure accomplish the same purpose.

Before beginning our work in this line we undertook to prepare thoroughly a field by a complete system of drainage. The land was naturally fairly well drained, but systematic drainage will largely overcome or counteract an excessive rainfall in any particular season. So that we have by this means done all that is possible for man to do in order to maintain an equilibrium in soil temperature, soil moisture and soil fertility. Whatever other influences may be brought to bear upon the crops grown upon the soil are such as man cannot control and upon which he cannot bring his efforts to bear, otherwise than as he may till the soil, or as he may apply plant-food in the form of barnyard manure, or as artificial fertilizers, such as he may purchase upon the market. When the farmer reaches the point where he thinks his land requires artificial manures, the important question that presents itself is, "what kind of fertilizers shall I buy?" He soon realizes that he can buy at almost any price, from three or four dollars up to fifty dollars or more per ton. This great variation in price is a perplexity rather than a safe satisfaction. Upon a closer investigation he finds that the price is in most cases governed by the elements contained, and furthermore by the quantity of such elements. These elements of plant food, which vary in price from 4 cents per pound up to 19 cents per pound, furnish another problem which only adds to his perplexity. To discover, by experimenting, requires time, patience and some means; furthermore a single experiment is liable to mislead. But just at a time when these questions are the rule rather than the exception, the Agricultural Experiment Stations established in the several States begin these investigations for the benefit of the farmers of the States in which they are located.

The land previously mentioned is a clay loam for about two feet to five feet deep; the underlying stratum is gravel. We give upon this page a diagram of the system of drainage, so that it may be more readily understood:

DIAGRAM



The broken line A, B, represents the main drain, which is about nine feet deep at A and three feet deep at B. From A the main drain extends some three hundred feet farther west, where it has a natural outlet. The broken lines beginning at *a, b, c,* etc., and extending into the line A, B, are the lateral drains. At their intersection with the main drain, they are of course, of the same depth as the main drain, but at the end *a, b, c,* etc., they are two and one-half feet deep. The object was to put these laterals 2½ to 3 feet deep, and any variations from that depth were caused by similar variations in the surface soil. The plats of ground between the unbroken lines, bearing the numbers 1, 2, 3, 4, etc., are thirty-four feet wide, and from the unbroken line to the center of the drain is one foot, hence we have thirty-six feet from the center of one drain to the center of another. These plats, 1, 2, 3, 4, etc., are again sub-divided by a space two feet wide, giving us plats 16 feet in width, as shown by the double line drawn through plat one. It is the expectation that the water will drain from the line O S to the drain *a x,* and from O S to *b r,* which, as already stated, is but eighteen feet either way to the drain. This system of drainage, as will be seen readily, gives each plat the advantage of a drain. In no case, however, does the drain come immediately under a plat, but it is in each case located at one side or the other of a plat, thus furnishing for one plat the same conditions that are provided for all the rest, or in other words, the circumstances surrounding each are identical.

It may be well to say here that this system of drainage extends over about sixteen acres of land, which after draining was

laid off in plats of tenth acres. Each tenth acre constitutes an experiment itself, but for the purpose of arriving at definite conclusions, the several experiments in their results are compared. This land was thus laid off, not for experiments in corn alone, but also for the same in wheat and oats, and a portion will be devoted to different systems of rotation.

The first series of plats that were laid out was twenty-two, each one-tenth acre in size. The ground this season was not plowed until quite late, on account of the ditching, which was completed about the 23d or 24th of May. The ground was plowed immediately, and after some dragging and harrowing, which was necessary to level it up, the fertilizers were applied broadcast and then harrowed in. The planting of corn was therefore not done until the 26th of May, the same day that the fertilizers were applied and the harrowing done. The ground was marked both ways, three feet nine inches wide, and Leaming corn planted. The ground was in excellent condition and the weather very warm, so that in three days after planting the corn was nearly all coming through the ground. The corn was harrowed on June 2nd, and received four workings with the cultivator afterwards, hence it received about such attention as the average farmer would be likely to give his corn. The hills were thinned to three stalks each, and each plot received treatment as nearly like all the others as was possible, except in the fertilizers applied. To sum up, the ground was all plowed upon the same day and harrowed, and the fertilizers were applied and harrowed in and the corn all planted upon the same date. The workings of the corn were uniform; that is, when one plot was worked all the rest were worked upon the same date. When, however, it came to cutting, some plots remained green a few days longer than others. These variations will be noted further on. The experiments are conducted for several purposes: First, does our land need artificial manures? If so, in what form? Must we apply them as single elements, such as potash, phosphoric acid, or nitrogen alone, or must we make it more expensive by adding two of these? Or can we combine the three and get results that will justify the additional outlay? Again, must we apply phosphoric acid as we can buy it in dissolved bone-black, or can we use Thomas' slag or South Carolina rock-phosphate with results equally good? Then the problem that comes up after all is, can we get any better results from these than from barnyard manures? These are some of the problems which the experiment with fertilizers on corn seeks to answer. Below we give a table containing the fertilizers applied and the results reached:

CORN TABLE VII—COMMERCIAL FERTILIZERS ON CORN.

Number of plat	Fertilizers applied	Amount of fertilizer applied per acre	Yield of shelled corn per acre as weighed from field	Yield corrected to full stand	Percent of ears	Percent of nubbins	Yield of stalks per acre	Yield of stalks corrected to a full stand
		Lbs	Bus.	Bus.			Lbs.	Lbs.
1	Unfertilized..... . ..	.....	82.5	86.0	76	24	7300	7600
2	Dissolved Bone-black..	300	79.8	83.0	78	22	5940	6195
3	Muriate of Potash.....	200	85.1	89.4	64	36	7040	7255
4	Unfertilized.....	.....	86.1	94.2	81	19	5900	6195
5	Nitrate of Soda..	480	82.	91.4	78	22	7500	8256
6	Nitrate of Soda..... Dissolved Bone-black..	480 300	93.2	96.8	79	21	6900	7171
7	Unfertilized.....	.....	90.4	93.0	80	20	6500	6689
8	Dissolved Bone-black.. Muriate of Potash.....	300 200	87.4	89.5	76	24	6500	6661
9	Nitrate of Soda..... Muriate of Potash.....	480 200	90 8	93.1	81	19	7600	7805
10	Unfertilized.....	....	90.5	92.1	76	24	7100	7271
11	Dissolved Bone-Black.. Muriate of Potash .... Nitrate of Soda... ..	300 200 480	75.8	85.7	68	32	6000	6959
12	Dissolved Bone-Black . Muriate of Potash... Nitrate of Soda.....	300 200 320	81.2	93.7	79	21	5600	6456
13	Unfertilized...	.....	74.8	90.5	78	22	6000	7260

CORN TABLE VII—Continued.

Number of plat	Fertilizers applied	Amount of fertilizer applied per acre	Yield of shelled corn per acre as weighed from field	Yield corrected to full stand	Percent of ears	Percent of nubbins	Yield of stalks per acre	Yield of stalks corrected to a full stand
		Lbs.	Bus.	Bus.			Lbs.	Lbs.
14	Dissolved Bone-black .... 300 Muriate of Potash ..... 200 Nitrate of Soda.... 160		73.7	89.2	71	29	5840	7087
15	Dissolved Bone-black .... 300 Muriate of Potash..... 200 Sulphate of Ammonia.... 120		77.2	88.	78	22	6540	7475
16	Unfertilized.....	.....	70.2	87.4	74	26	4500	5606
17	Nitrate of Soda..... 480 Muriate of Potash.. ..... 200 Rock Phosphate..... 300		78.1	89.2	79	21	6400	7235
18	Nitrate of Soda..... 480 Muriate of Potash ..... 200 Slag Phosphate..... 400		75.1	89.4	75	25	5600	6670
19	Unfertilized.....	.....	72.7	78.6	66	34	6000	6538
20	Barnyard Manure.....	16 Tons	79.5	93.9	75	25	4940	5866
21	Linseed Oil-meal	180	86.2	105.2	80	20	6200	7573
22	Unfertilized.....	....	84.5	100.0	79	21	5540	6601

After carefully looking over table seven we must conclude that our work, although done with the utmost care and precision, has not answered satisfactorily any of the questions which we have proposed; but it does seem to answer one which we were not seeking with the same interest that we were some others, and that is the fact that our soil does not need artificial manures, and furthermore,

that the money used in buying these commercial manures was simply money expended without any return. This is a very important point with the farmers of Ohio today, and should call attention to the fact that artificial manures do not necessarily, when applied, increase the yield. If our land already has abundant plant food in available form, then the application of any manure is superfluous, or in other words, a waste of time and means. Not having found any increase in the yield, we will prepare another table in which we ask the questions, does the corn grown from one kind of fertilizer shrink more than corn grown from some other kind, or does one kind of fertilizer produce more corn and less cob than another? Table eight will show results on this point.

CORN TABLE VIII—SHRINKAGE AND AMOUNT OF CORN COMPARED WITH THE AMOUNT OF COB IN EACH 100 LBS.

No. of Plat	Kind and Amount of Fertilizer applied	Weight in the Field Nov. 17	Weight Jan. 25	Loss	Weight of Shelled Corn	Weight of Cobs	Weight of Measured Half Bushel
		lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
1	Unfertilized	100	85	15	69	16	27
2	Dissolved Bone-black, 300 lbs	100	84	16	67	17	27
3	Muriate of Potash, 200 lbs	100	82	18	66	16	27
4	Unfertilized	100	80.5	19.5	66	14.5	25.5
5	Nitrate of Soda, 480 lbs	100	80	20	65	15	26
6	Nitrate of Soda, 480 lbs. / Dissolved Bone-black, 300 lbs.	100	81	19	65	16	26
7	Unfertilized	100	86	14	69	17	27
8	Dissolved Bone-black, 300 lbs. / Muriate of Potash, 200 lbs	100	84	16	67	17	25
9	Nitrate of Soda, 480 lbs. / Muriate of Potash, 200 lbs	100	83	17	67	16	26
10	Unfertilized	100	83	17	67	16	26
11	Dissolved Bone-black, 300 lbs. / Muriate of Potash, 200 lbs. / Nitrate of Soda, 480 lbs	100	84	16	67	17	26

An examination of table eight does not reveal any effect from the fertilizers. We find some variations in shrinkage, some variations in amount of shelled corn from one hundred pounds of corn as weighed in the field, also some variations in amount of cobs from a hundred pounds of corn; but these differences are slight, and furthermore the differences in weight are as great between plats having the same treatment as they are between plats having entirely different treatment; hence we cannot draw any conclusions. This

experiment then, throughout, is in general terms of no particular benefit while it stands alone as a single test. We call attention however, to the exceptional season, namely that it has been a favorable one in nearly every respect, and especially suited to corn growth. Under less favorable conditions our work might have given quite different results. As it is we give it to the public with the explanation that the same experiment will be continued for a series of years upon the same plats, hence this season's work will be considered in after years and the proof of the fertility of the land as demonstrated by this year's work may be of importance and interest in the years to come.

It should be stated that the negative results of this test are precisely what was expected when the work was undertaken. It is expected, however, that as the natural fertility of the soil becomes exhausted, by continuous cropping, the effects of fertilizers will be made more apparent.

Branch Station Work

The Experiment Station, as a means of widening its usefulness, has undertaken a limited amount of work in other parts of the State, where the soil is altogether different from the land at the station proper. This work is what we term sub-station work. The object of this is patent to any one who has any knowledge whatever of the great variation of soils and of their needs. It is generally understood by the farmers that the needs of one soil are not necessarily the needs of other soils, but that an application of certain fertilizers to one soil may increase its yield tenfold, while the same fertilizer applied to a soil twenty miles away may not have any effect whatever. This sub-station work will enable the station to study the different soils of the state, to inquire into their characteristics and determine their most economic treatment. It is hoped that this system of investigation will eventually prove to be a great benefit to the agricultural interests of the several parts of the state, for, if it is properly carried out, a few years at most should suffice to give us a general outline of the various soils of the state, and an approximate idea as to what fertilizer or combinations of fertilizers can be applied most economically. These are problems of most vital interest to our farmers today, and while their solution cannot be given in a few days or months, yet we believe it can be given in a few years.

One of these sub-stations has been located in the eastern part of the state (Columbiana Co.). The location is on a high "soapstone" or slaty point. This stratum of slate is possibly ten feet

deep, and that, with its elevation, gives abundance of natural drainage. The natural condition of this kind of soil is quite loose and open, always easily worked. We are justified in saying that fully one-half of this soil is made up of small slate stones from the size of a ten-cent piece up to and somewhat larger than a silver dollar. In general terms it is considered poor land—just the place for such investigations as we wish to make. Owing to the fact that the Experiment Station was not completely organized under the Hatch Act until the first of April, 1888, our work was somewhat retarded al laround, hence arrangements for this sub-station were not completed until late in May. The object of this sub-station was to duplicate experiments made at the central station, the outline, plan, and special features of which have been given and also the results. It may be noticed, however, that we have curtailed somewhat the work here, for, while the plan given shows twenty-two plats of one-tenth acre each, the sub-station has only fourteen plats of one-tenth acre each. The ground was plowed and harrowed May 18th; fertilizers were sown broadcast and harrowed in on May 21st; and the corn planted on May 22d, rows three feet six inches apart, and hills three feet six inches apart in the row. The same points were observed in carrying out this experiment as were described for the more elaborate one on the preceding pages. The ground was laid out and the general work looked after by the Agriculturist of the station, but the carrying out of the details and the immediate supervision was done by Mr. Henry Bentley, free of charge to the station. To him belongs credit for the care and attention given the work. In Table 9 we give fertilizers applied and results obtained.

CORN TABLE IX—EXPERIMENTS WITH FERTILIZERS ON CORN. AMOUNT OF CORN AND FODDER PER ACRE FROM DIFFERENT FERTILIZERS.

Number of Plat	Fertilizers Applied	Amount of Fertilizer applied per acre	Yield per acre of Corn as weighed from the field. (Shelled Corn)	Yield corrected to a perfect stand	Weight of fodder per acre	Weight of Fodder corrected to full stand
		lbs.	*bus.*	*bus.*	*lbs.*	*lbs.*
1	Unfertilized	.....	33.4	51.7	4220	4520
2	Dis. Bone-black	300	34.2	53.8	4420	4640
3	Muriate of Potash	200	37.7	56.8	4820	5050
4	Unfertilized	.....	40.8	60.3	4440	4770
5	Nitrate of Soda	480	67.1	76.7	5480	5800
6	Nitrate of Soda Dis. Bone-black	480 300	85.4	93.2	5700	6030
7	Unfertilized	.....	65.7	94.5	4240	4580
8	Dis. Bone-black Muriate of Potash	300 200	66.5	91.8	5060	5390
9	Nitrate of Soda Muriate of potash	480 200	87.1	94.7	6340	6590
10	Unfertilized	.....	65.7	86.4	4620	4960
11	Dis. Bone-black Muriate of Potash Nitrate of Soda	300 200 480	71.1	94.8	6180	6500
12	Barnyard Manure	16 tons	58.5	89.5	4860	5140
13	Unfertilized	.....	56.2	86.0	5090	5530
14	Common Salt	400	56.2	84.5	5420	5810

In reading over table nine, in the column of actual results or in the column where the results are calculated for a full stand, we would be led to believe that the land is not strictly uniform, but that there is a gradual increase in fertility or productiveness from plat one up to plat seven or eight. A superficial survey of the soil or land would not confirm this idea, but the product from a practical standpoint is sufficient proof of at least a slight variation in productiveness. A careful reading of the third column of figures from plat one up to and including plat four shows this variation or change to be a very gradual and regular one. The causal or careless observer, after reading this table over would probably pronounce it of no value; but let us take the unfertilized plats and we find the average actual yield of plats one, four, seven, ten and thirteen (all unfertilized) to be fifty-two and three-tenths bushels per acre. The possible product from these five plats, if all the stalks had borne ears averaging the size of those that did bear, would be seventy-five bushels per acre. Now we are aware that we can select results and bring out any point that we might desire

to do, but not without ignoring or suppressing some important feature. But this manner of selecting these unfertilized plats is entirely legitimate, for by taking them as a whole we arrive at the proof of what this land would produce without fertilizers, as it will be observed that they occur as every third plat, hence are distributed through the whole series in regular order.

Averaging plats two and eight, to which we have applied dissolved bone and muriate of potash, we find our results to be 50.3 bushels actual yield and 72.8 bushels possible yield per acre; comparing this with the results from the unfertilized plats, we reach the conclusion that phosphoric acid as applied in dissolved bone, either alone or in combination with muriate of potash has not in this case benefitted our crop.

Averaging plats three and eight, to which we have applied muriate of potash and dissolved bone-black, we get an average yield of 52.1 bushels actual yield and a possible yield of 74.3 bushels. We here have reason to believe that potash applied either alone or combined with phosphoric acid has failed to give us any increase in yield. Now taking plats five, six, nine and eleven, all of which have received an application of nitrogen in the form of nitrate of soda; we discover that our results average 77.6 bushels per acre actual yield, with a possible yield of 92.1 bushels. This seems to give definite evidence of beneficial results from the application of nitrogen, either alone or in combination with phosphoric acid and with potash. Now taking all the plats not treated with nitrate of soda, namely 1, 2, 3, 4, 7, 8, 10, 12 and 14, and we get an average yield of 50.9 per acre and a possible average yield of 75.3 bushels per acre. Comparing these figures with the above results from those plats to which nitrogen was added we find that the plats receiving nitrogen have averaged more than fifty percent better actual yield to the acre, and within about twenty percent of a possible yield. To explain the cause of this greater yield we give table ten, and after giving the figures we will point out the items of interest.

It will be observed that the plat to which barn yard manure was applied did not give any increase in yield. This point is not readily accounted for, since the conditions for such manure being appropriated for plant food were favorable. We hope to try the same experiment on the same ground the coming season and this will be one of the points to be looked after. There is another plat upon the same series that has surprised us somewhat, namely, that the yield of the plat receiving the complete fertilizer has not been higher than any of the rest. This gives another point of interest for us to watch more closely.

CORN TABLE X—EXPERIMENT WITH FERTILIZERS ON CORN (Continued).

TABLE SHOWING PERCENTAGES OF EARS AND NUBBINS FROM DIFFERENT FERTILIZERS; ALSO SHOWING NUMBER OF STALKS NOT BEARING EARS.

Number of plat	Kind of fertilizer and amount applied	No. of stalks that did not bear ears	Percent of ears	Percent of nubbins
1	Unfertilized	304	74	26
2	Dissolved Bone-black, 300 lbs	312	66	34
3	Muriate of Potash, 200 lbs	286	65	35
4	Unfertilized	252	71	29
5	Nitrate of Soda, 480 lbs	69	84	16
6	Nitrate of Soda, 480 lbs. / Dissolved Bone-black, 300 lbs.	30	86	14
7	Unfertilized	228	80	20
8	Dissolved Bone-black, 300 lbs. / Muriate of Potash, 200 lbs.	196	81	19
9	Nitrate of Soda, 480 lbs. / Muriate of Potash, 200 lbs.	41	86	14
10	Unfertilized	169	77	23
11	Dissolved Bone-black, 300 lbs. / Muriate of Potash, 200 lbs. / Nitrate of Soda, 480 lbs.	197	82	18
12	Barn-yard Manure, 16 tons per acre	288	78	22
13	Unfertilized	253	71	29
14	Common Salt	264	71	29

Our experience with the kind of soil upon which this experiment was carried out has, in years gone by, revealed the fact that it produces many barren stalks, some of which make a slight effort to produce ears, but the greater portion do not even have the appearance of having started an ear; it has, however, never occurred to us that the proportion of barren stalks was anything like as great as this work has brought out. It has already been stated that these hills were three feet and one-half apart each way, and that each hill was composed of three stalks. This gives us a possible 990 stalks to each plot. Having counted the ears, nubbins, and the missing stalks, we can easily estimate the number of barren stalks. These we have placed in the first column of Table X, a glance at which shows the secret of the beneficial results from the use of fertilizers containing nitrogen. The number of stalks on these several plats varied but little, but the number bearing ears or nubbins of corn varied considerably. Upon the unfertilized plats the average

not bearing ears was 241 stalks. Upon the plats to which dissolved bone alone was added and where dissolved bone and muriate of potash were used together the average of barren stalks was 254.

When potash was applied alone and in combination with dissolved bone, the average of barren stalks to each tenth-acre was 241; but where nitrogen as nitrate of soda was used, not only alone, but also in combination with each of the others, the number of barren stalks is reduced to an average of 84 to each tenth acre. The same process of calculation brings out similar percentages of ears and nubbins, that is, where the nitrate was not used, the percentage of ears was decreased and the percentage of nubbins increased; and where the nitrate was used, the percent of ears was increased and the percent of nubbins decreased.

There is another point that we wish to mention, and that is the fact that during the growing season, the plats to which nitrate of soda was applied could be distinguished from the others at a disance of one hundred rods. There were two points of distinction, namely, in size and in color. These nitrate plats were a little ahead all the way through. But after the nitrate plats seemed to have ceased their upward growth, the others continued to grow, and, eventually, the several plats were apparently of the same height. But even after this, the nitrate plats could still be distinguished by their color. We were not able to make any observations after these plats reached their growth. There is a possibility that these nitrate plats matured earlier than the others, but we have no evidence upon that point, either pro or con. We failed to call attention to the fodder product in Table 9, but if the reader is sufficiently interested to make the calculations, he will find that the results will correspond with our deductions, but the variations will not be nearly so great. The reason of this is apparent when we remember that the number of stalks to each plat is almost identical. It will be observed, however, that where a larger proportion of ears were produced, the fodder weight was also increased.

Conclusions

From the experiment conducted on the station land we can find some slight indications of the effects of the fertilizers, but they are so slight that we deem it best not to attempt to draw any definite conclusions from this single experiment, futher than to say that in our opinion the work gives evidence that a soil that will produce from eighty to one hundred bushels of shelled corn per acre is not benefitted by the addition of commercial fertilizers.

First.—This work proves first that the plan of experimenting is not at fault, but shows results proving that the application of commercial manures is in some cases attended with good results.

Second.—It indicates that potash and phosphoric acid applied either alone or the two combined do not increase the yield over unfertilized land.

Third.—It shows that nitrate applied either alone or in combination with either phosphoric acid or potash, or applied in combination with both, add to the yield per acre.

Fourth.—The increase in yield is made in two ways: first by causing many of the otherwise barren stalks to produce ears, and second by reducing the percentage of nubbins.

Fifth.—Nitrates used alone or in combination also increased the weight of the fodder per acre.

In conclusion I would emphasize the point that the above does not apply to every soil, but shows the effects of artificial manures upon a particular kind of soil.

J. FREMONT HICKMAN, *Agriculturist.*

In addition to the foregoing experiments, the following tests bearing upon the same question have been made under the immediate supervision of the Director of the Station.

(I.) A TEST ON THE SANDY SOIL OF NORTHWESTERN OHIO

On the line between Fulton and Henry counties there is an extensive stretch of flat, sandy land, originally marshy prairies, divided by low flat ridges, covered with a somewhat stunted growth of timber, and locally known as "the openings." This territory comprises an area of about 300 square miles. It is now being drained, and the marshy portions make excellent farming land, but the intervening low ridges of yellow sand yield very poor crops for some time after being cleared and brought under the plow, though they gradually improve under culture.

On one of these sandy ridges an experiment was instituted last spring, the exact counterpart in general plan of the one made in Columbiana county. The land had been cleared during the previous winter, and the clearing was not finished until late in the spring, consequently the planting of the corn was delayed until the last of May. On the first of September an untimely frost killed the crop, while the corn was still immature, and hence no satisfactory report of comparative yields can be made. The field was visited

by the Director on the second day after the frost, and three points were observed which are worth recording. These were: (1.) Even after the frost, from a distance of forty rods or more, the plots which had received nitrate of soda could be easily distinguished from the others by their deep green color. (2.) On two adjoining plots, the one having received no fertilizer, and the other a complete fertilizer containing a large quantity of nitrate of soda, the yield on the first one was practically nothing, the stalks being not more than four or five feet tall with only occasionally an immature nubbin, while in the second case the stalks were nine or ten feet tall, and the development of ears indicated a yield of not less than thirty bushels of shelled corn per acre. (3.) The plots receiving the phosphoric acid and potash showed a slightly better development than those receiving no fertilizer, but their yield could not have reached half that of the plot receiving the complete fertilizer.

The foregoing test was made upon the ancient beach of Lake Erie, the Maumee River having once been an arm of the lake. As a check upon this test, an experiment was made upon the sand constituting the present beach of the lake, a few barrels of which were transported to the Station for this purpose. The details of this experiment were carried out by Mr. W. H. Baker, a student at the State University, whose report follows:

Experiments with Fertilizers on Corn Grown in Boxes

"In this experiment two series of boxes were used. Series 1 consisted of ten boxes filled with Lake Erie sand; Series 2, of ten boxes filled with earth taken from the north field of the experiment farm. The boxes used were 18 inches square by 12 inches deep, made of pine boards and lined with zinc, having an opening at the bottom for drainage. The fertilizers in the first eight boxes of a series were the simple salts, and the total amount applied to each box was the same. As it was not desired to experiment in regard to the quantity, care was taken only to give the plants an abundance of each fertilizer. Three applications were made, one at date of planting, one July 14, and one Aug. 18. About 2 pounds of yard manure was applied to No. 9, and about 4 ounces of linseed meal to No. 10; these were not renewed. Corn was planted in the sand on May 23, and in the earth on May 26. Three plants were grown in each box. The plants were watered artificially whenever necessary, and the soil was frequently stirred without disturbing the roots. Corn of the same variety (Leaming) was planted in some

quantity around the boxes, to insure fertilization of the flowers. Careful weekly notes and measurements were taken of the growth and appearance of the plants. The harvesting was done by taking the entire plant from the box and carefully removing the soil from the roots, which were weighed as part of the fodder. The following table will show the greatest height of plants in each box, the weight of the plants and the weight of shelled corn after being well cured:"

TABLE XI—CORN GROWN IN BOXES.

		Series 1			Series 2		
		Soil—Lake Sand			Soil—Earth from Field		
No.	Fertilizer	Height	Wt. of Corn and Fodder Dec. 8	Wt. of Shelled Corn Dec. 8.	Height	Wt. of Corn and Fodder Dec. 8	Wt. of Shelled Corn Dec. 8
		In.	Oz.	Oz.	In.	Oz.	Oz.
1	Unfertilized	38	.62	.....	84	20.50	2.50
2	Superphosphate	48	2.	.....	102	15.75	1.25
3	Muriate of Potash	47	1.12	.....	102	21.	.87
4	Nitrate of Soda	56	2.75	.....	95	23.	7.75
5	Superphosphate and Potash	60	2.	.....	92	17.	1.25
6	Superphosphate and Nitrate	77	6.25	1.62	102	24.50	5.
7	Potash and Nitrate	54	1.75	.....	96	14.37	3.37
8	Superphos., Potash and Nitrate	87	9.50	2.25	90	20.37	3.25
9	Stable Manure	59	3.25	.....	98	17.50	4.75
10	Linseed Oil-meal	73	3.25	.....	108	20.75	2.62

In the case of the corn grown in lake sand, it will be noted that the only cases where any grain was produced were those in which nitrate of soda and superphosphate (dissolved bone-black) were combined. Potash alone seems to have absolutely no effect; yet, when combined with superphosphate and nitrate of soda, potash produced a marked increase.

In the case of the corn grown in the soil of the experiment field, it seems that nitrogen alone was the element needed. It will be noted that the box receiving only nitrate of soda shows the greatest yield of grain. A partial explanation may be found in the fact that this box received a much larger quantity of nitrogen than boxes 6 and 8. In this series of tests, no effort was made to use the

fertilizers in the proportions they would be used in field tests. The only point aimed at was to determine the relative effect of nitrogen, phosphoric acid, and potash upon the growth of the corn-plant. In applying the fertilizers, therefore, they were simply masured with a spoon, and, owing to a misunderstanding of instructions, Mr. Baker applied the same *bulk* of fertilizer to each box at the second and third applications. The result was that box 8 got each time one spoonful each of nitrate, superphosphate, and potash salts; boxes 6 and 7 got 1½ spoonfuls each, and box 4 got 3 spoonfuls of nitrate, or twice as much as boxes 6 and 7, and three times as much as box 8. A discrepancy will be noted between the yields of boxes 6 and 7, both receiving the same quantity of notrogen; but box 6 was fertilized with superphosphate, and box 7 with potash. Compare these with boxes 2, 3, and 5, and this discrepancy is easily accounted for. There is still another discrepancy, which is that box 1 unfertilized, yielded more than boxes 2, 3, and 5, receiving superphosphate and potash. It is not safe to conclude from this that the superphosphate and potash were injurious; but the probability is that one or more of the plants growing in this box possessed a greater degree of vigor than those in the other boxes, or, that some accidental source of fertility reached this box undetected by the experimenter. Hence, the conclusion indicated by this test must be accepted as *indicative only*, to be verified or reversed by subsequent tests. As it stands, however, this test shows that the four boxes receiving no nitrogen yielded a total of 5.87 ounces of shelled corn, while the four boxes receiving nitrate of soda yielded a total of 19.37 ounces, an increase of more than three-fold.

Conclusions

The experienced experimenter is extremely cautious in drawing conclusions, and hence we insist that the results indicated and the work herein described be treated and accepted simply as indicative, until further evidence is produced. These results indicate that for the varied soils upon which these tests have been made, the element of first importance in a fertilizer for corn is nitrogen, and that, contrary to the accepted belief, the use of phosphoric acid and potash without nitrogen is fruitless.

We have one more word of caution to offer: nitrate of soda, which we believe to be the cheapest source of the nitrogen of artificial fertilizers, costs 2⅜ to 2½ cents per pound at wholesale in the New York market. For the dissolved bone-black used in these experiments, the station paid $26 per ton in New York, and for the

muriate of potash, $42.50 per ton. From these prices farmers can calculate the cost of each form of fertilizer used and from the yields given he can determine the value of the increase of crop.

On the great Rothamsted experiment farm of Sir John B. Lawes, of England, wheat has been grown for more than forty years in succession, both without any fertilizer whatever and with various kinds and combinations of fertilizers. On this farm the plat that has received no manure or fertilizer whatever throughout this period has yielded an average of 13⅛ bushels per acre for the 34 years ending with the harvest of 1887. A plat receiving annuaally a dressing of 800 pounds salts of potash, soda, and magnesia has given an average yield of 13 bushels. A plat receiving annually a dressing of more than half a ton of superphosphate per acre has yileded 16¼ bushels per acre; a plat receiving one-third this amount of superphosphate and half the quantity of potash given to the plat receiving potash, soda, and magnesia yielded 15¼ bushels. When, however, 550 pounds nitrate of soda was added to the dressing of superphosphate and potash, the yield rose to 36¼ bushels per acre over the entire period. Now, while the results of the experiments made this year at the Ohio station with corn can only be accepted as indicative, at the present stage of the work, yet it will be seen that they are in harmony with the results obtained at this English station with wheat, over so long a period that they must be accepted as *demonstrations* for that soil.

Statistics collected by the assessors of Ohio show that the farmers of this state are annually expending more than half a million dollars in the purchase of commercial fertilizers. The analyses made by the State Board of Agriculture show that in the great majority of the brands of fertilizers sold in the state, nitrogen exists in a very small portion relatively to phosphoric acid and potash. The question now arises, are we exercising true economy in the purchase and use of these fertilizers, or is it not possible—even probable—that by purchasing largely of the relatively lower priced phosphoric acid and potash we are really accomplishing less than might be accomplished by purchasing the higher priced nitrogen? The question is one that can only be settled by actual experiment, and experiments made on the soil cannot be accepted as a guide for different soills. The object of this bulletin is to arouse the farmers of Ohio to personal investigation on this question. For the conduct of this investigation the station offers its aid and cooperation, and it is hoped that farmers in all parts of the state will join hands with us in the work. To this end correspondence is invited.

CHAS. E. THORNE, *Director.*

NOTICE

BULLETINS

The present issue closes the series of bulletins of the Ohio Agricultural Experiment Station for 1888. These bulletins have been sent to a large number of farmers who had not directly applied for them, but whose names were found on the books of the Station as recipients of its publications in previous years. As it is not desirable to send these publications to any who do not care for them, this practice will be discontinued, and hereafter the bulletins will be sent only to such as signify a desire to receive them. All such are requested to fill out and return to the Station the enclosed card, headed "REQUEST FOR BULLETINS."

ANNUAL REPORTS

The annual report of this Station for 1887 is now ready for distribution, and that for 1888 will soon be in the printer's hands. Of its annual report the Station has but 5,000 pamphlet copies for distribution, and there are more than 7,000 names on its bulletin list, and new names are being added at the rate of one hundred or more weekly, it is evident that all these names cannot be supplied with copies of the pamphlet addition of the annual report. A duplicate edition of this report, however, is bound in the same volume with the annual report of the State Board of Agriculture, of which 24,000 copies were printed, for distribution by the Secretary of the Board of Agriculture (Columbus), by members of the legislature and by county auditors. Many persons would rather have the Station report in this form than in the pamphlet edition, therefore we request those who have received or who expect to receive the report of the State Board of Agriculture *not* to apply to the Station for its annual report, unless for some special reason they desire an extra copy. We wish it distinctly understood that this request is made solely in order that as many as possible may receive our reports. These reports are published for the benefit of the farmers of Ohio, and we wish to secure for them as wide a distribution as possible. With this explanation, we request those who wish a copy of the pamphlet edition of the annual reports of the Station for 1887 and 1888 to fill out and return to the Station the enclosed card, headed "REQUEST FOR ANNUAL REPORTS." We ask that you do this, as such applications have been held until this explanation could be made.

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Columbus, Ohio.